Measuring the Spatial Distribution of Ripples Using a REMUS AUV

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Award Number: N00014-04-1-0625

LONG-TERM GOALS

The long term goal is to develop and apply new technology to make better measurements of the spatial distribution of bedforms in both low wave conditions and especially in more energetic conditions.

OBJECTIVES

The specific objectives of this program are 1) to develop the capability in an autonomous underwater vehicle to measure bedform amplitude with resolution of 1 cm in the vertical and several cm in the horizontal direction; 2) to apply this technology in the Ripples DRI program to resolve the along- and across-shelf variations of bedform amplitude and wavelength across the West Florida shelf during varying wave-forcing conditions; 3) to make surveys in the strongly forced inner shelf region near the Martha's Vineyard Coastal Observatory to examine short-term changes in bedforms due to changes in wave forcing and to test the ability of the system to measure topography during energetic conditions.

APPROACH

This project is part of the Ripples DRI, in which the spatial and temporal variations of the seabed are being examined in a field site on the West Florida shelf. We are using the autonomous underwater vehicle (AUV) REMUS (Figure 1) to make better measurements of the spatial distribution of active ripples as they are modified during increasing sea-states. The AUV is equipped with a sidescan sonar to measure ripple geometry and a pencil-beam sonar to measure ripple height. The AUV is being used to survey across a range of water depths, including the SAX04 intensive measurement site and ranging in water depth from 3- to 50-m. Repeated surveys at varying water depths complement the high-resolution measurements at the intensive site, documenting the broader spatial scales of variation of bedform structure. We are also deploying a bottom tripod (Figure 1) with a pencil beam sonar to measure ripple height, a rotary fan beam sonar to image ripple topography, and a ADV to measure wave and current hydrodynamic forcing. In addition to the measurements on the West Florida shelf,

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
SEP 2004		**00-00-2004 to 00-00-2004**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Measuring the Spatial Distribution of Ripples Using a REMUS AUV	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,,Applied Ocean Physics and Engineering,98 Water Street, MS #12,,Woods Hole,,MA,02543**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**5**	

we also plan to perform measurements near the Martha's Vineyard Coastal Observatory to obtain more data on response of the bed to changes in wave forcing.

WORK COMPLETED

In order for the Remus vehicle to measure ripple amplitude, an Imagenex pencil beam echosounder was integrated into the vehicle. A series of evaluation and calibration tests were performed on the echosounder by a summer student fellow during June through August 2004. The tests were conducted in a 1.5 m deep tow tank that was capable of generating sand ripples by attaching a sand tray to the tow carriage and oscillating the tray with a frequency and excursion similar to surface gravity waves. Tests were also conducted to determine the noise level of the inertial navigation unit, which determines the system's ability to remove wave-induced vehicle motion from the bathymetry signal.

The first field measurements on the west Florida shelf have just been completed at the time of submission of this report. The bottom tripod was deployed, and a successful set of Remus missions provided along-shelf and across-shelf coverage at water depths from 3- to 50-m.

RESULTS

Technical Developments

The 1.25 degree beamwidth of of the Imagenix sonar provides 2 cm resolution at 1-m range. The tests indicated the sonar was capable of measuring the local seafloor elevation with a r.m.s. error of 0.25 cm at a sampling rate of 50 Hz. This allows the resolution of bedforms with a minimum wavelengh of 10 cm and height of 1.5 cm at a vehicle speed of approximately 1 m/s. It is anticipated that it will measure large ripples quite easily.

Preliminary Results of First West Florida Survey

As of the submittal of this report, the first field effort had just been completed. A preliminary look at the Remus data indicated that ripples were found throughout the shelf (Figure 2), from the furthest inshore survey locations at 3-m depth to the furthest offshore, at 50-m. The ubiquitous ripples found in deep water were the result of the energetic waves associated with Hurricane Ivan. Ripples in shallower water may have reformed during moderate wave energy events since Ivan, but before our survey. The side-scan imagery do indicate transitions between rippled and non-rippled bed (Figure 3), pressumably associated with changes in grain size from sand to mud. Areas of 3 to 10m scale mud patches were found between 10 and 15 m water depth.

IMPACT/APPLICATIONS

This new capability of Remus to quantify variations in bedform elevation has implications both for research and for naval operations. The system provides unprecedented combination of high resolution and large spatial coverage of seabed conditions that can be related to seabed mobility and potential for mine burial.

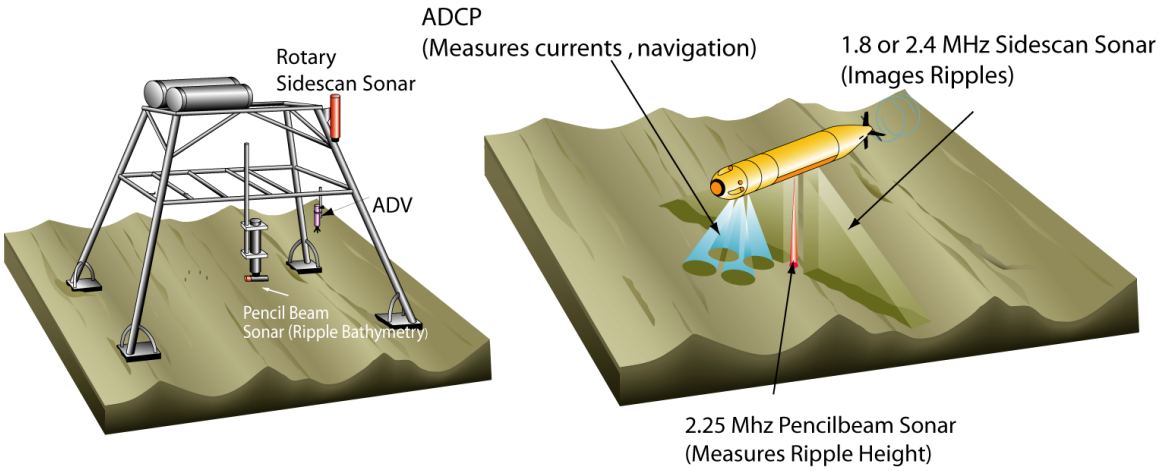

Figure 1

[Left: A bottom mounted instrument frame to measure the temporal evolution of ripple parameters at a single location as part of the RipplesDRI experiment off of Fort Walton Beach Florida. Instruments on the frame include a pencil beam sonar to measure ripple height, a rotary fan beam sonar to image ripple topography, and a ADV to measure wave and current hydrodynamic forcing. Right: An Remus AUV is being used to measure the spatial distribution of bedforms during two cruises at the Florida site, and at the Martha's Vineyard Coastal Observatory. The AUV has a sidescan sonar to image ripple topography and a pencil beam echo sounder to measure ripple height.]

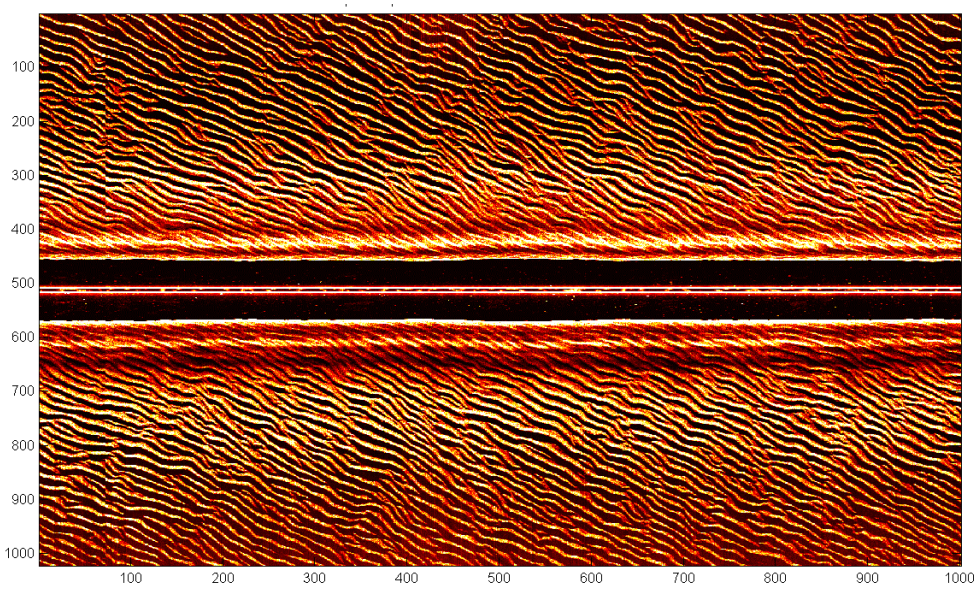

Figure 2.

[Side-scan image of ripples at 50-m water depth, near the seaward limit of the survey. The units shown on the plot are pixels; the overall field of view is approximately 50-m wide and 120-m long. The ripples in this image have wavelengths of approximately 1-m. Remus was flying approximately 3-m above the bed at this time.]

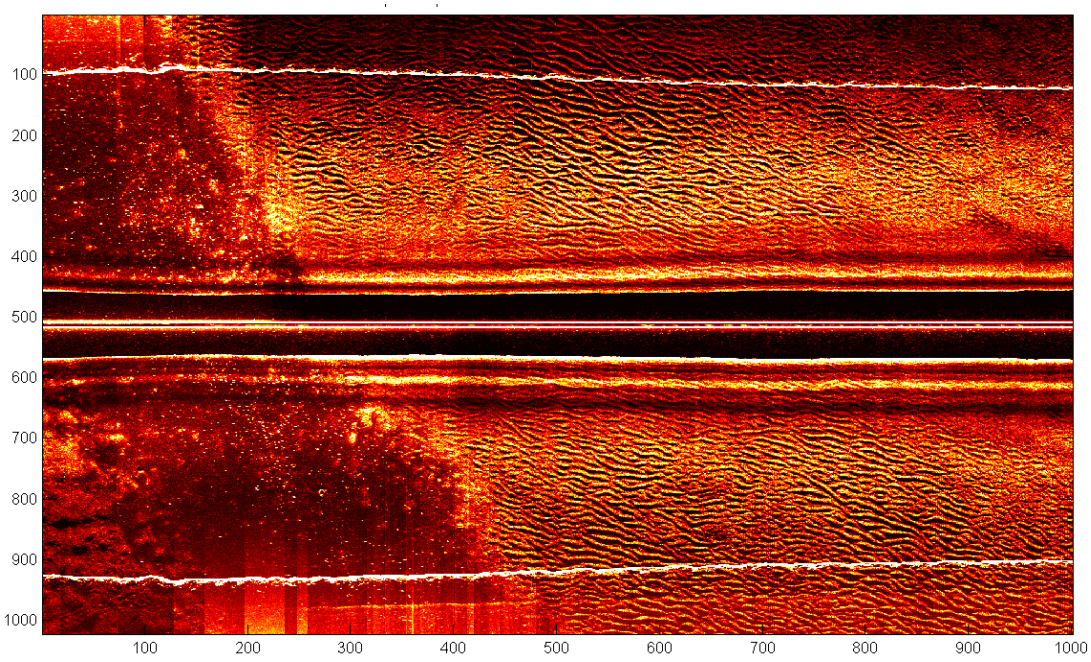

Figure 3.
[Side-scan image at 25-m depth showing a transition from mud (left side) to rippled sand]